Small Animal Intrusion Detection Based on RAFT

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Abstract

Due to the variety, size and shape of the invasive animals in substation, the general target detection and case segmentation tasks are often faced with the problems of fewer data and lack of diversity. Optical flow estimation can accurately detect the boundary of the moving object through the change of optical flow during the moving process of the object. Therefore, RAFT for small animal intrusion detection can not only effectively eliminate the interference of non-invasive objects, but also cancel the range of intrusion targets, and improve the generalization ability of moving object intrusion detection. The experimental results show that the detection effect is good for small invasive animals with low speeds.

Keywords: *RAFT, small animal intrusion detection, optical flow estimation*

I. Introduction

Electricity is closely related to people's lives in modern society, therefore the interruption of the power supply may cause very serious impacts such as production stagnation, life chaos or even endanger the safety of people and equipment. And the loss of power outage to the national economy far exceeds the loss of power system itself. Hence, the primary requirement for power system operation is to ensure the reliability of system operation. Since the transmission line is located outdoors, it is inevitably affected by the invasion of small animals in surrounding environments. Especially in winter, when the temperature turns cold, small animals such as rats and snakes begin to find nests to hibernate. In addition to the higher indoor temperature in the substation, it can easily become the "best hibernation" for small animals. In places, gnawing and destroying cables or entering the equipment can easily cause short-circuit, insulation damage and other accidents, which poses a threat to the safe operation of the equipment. However, at present most substations are unmanned stations, and the interval of regular inspections are difficult to adapt to the irregularity and contingency of animal intrusion. Therefore, a continuous monitoring device for foreign body intrusion in the substation is urgently needed.

Intelligent video surveillance combines artificial intelligence, computer vision, pattern recognition, target detection and other technologies to analyze video, providing technical means for small animal intrusion. Real-time detection of high-voltage switch cabinets, junction boxes, control cabinets, protection screens, etc. Once a small animal invades, an alarm can be issued to the staff, which can greatly reduce the cost of petrol and monitoring.

Small animal intrusion detection methods belong to the scope of moving object detection, mainly including the traditional image processing methods such as optical flow method [1, 2], inter-frame different methods [3], motion compensation method [4, 5], while these methods have high performance, the detection accuracy is relatively low. With the rise of deep learning, target detection algorithms (one-stage target detection Yolo series, SSD, two-stage Faster CNN, etc.) and image segmentation algorithms can also be used for small animal intrusion detection, however, a large amount of data is required as a training set for training the model. In addition to algorithmic update iterations, hardware devices are also constantly innovating. Some researchers use infrared cameras [6, 7] to

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monitor the invasion of small animals according to the different infrared rays of the animals with the surrounding environment. However, it requires a higher infrared equipment cost and the infrared image still needs the above-mentioned traditional image processing algorithm or deep learning algorithm for detection. Comprehensively considering the above problem, this article proposes the use of RAFT to detect invading animals. RAFT is a neural network-based optical flow estimation, which uses the changes in the time domain of pixels between adjacent flames or interval flames and the correlation of adjacent pixels to obtain optical flow information of moving objects. The network can be trained through public data sets, which solves the problem of massive training data required for target detection and segmentation tasks.

II. Image Segmentation Based on RAFT

RAFT is a neural network based on optical flow estimation, which uses the changes in the time domain of pixels between adjacent frames or interval frames and the correlation of adjacent pixels to obtain optical flow information of moving objects.

2.1 Introduction to dense optical flow estimation

Dense optical flow describes the optical flow of each pixel of the image moving to the next frame, uses different colors and brightness to indicate the size and direction of the optical flow. Figure 1 shows a mapping relationship between optical flow and color, using color to indicate the direction of optical flow, and brightness indicate the size of optical flow.

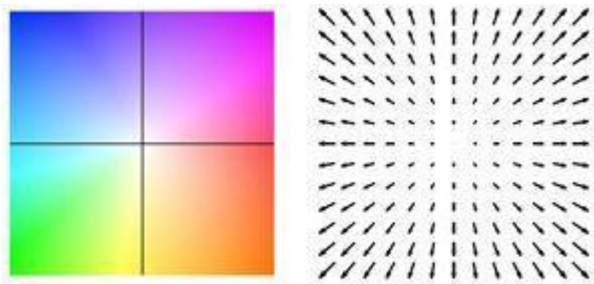

Figure 1 Dense optical flow representation

2.2 Introduction to the RAFT network

The RAFT network structure can be seen in Figure 2. This project uses a 4.8M parameter model. On the left part are the Feature Encoder and the Context Encoder, two adjacent frames of images (l1, l2) will be extracted by the feature extractor, which outputs a 1/8-size feature picture. The context extractor only processes the l1 image to ensure that the estimation optical flow diagram maintains the same context information and position information as the original image. Next, a similar block is established. Each pixel on the feature generated by the first frame image is subjected to a dot product operation (point similarity measurement) with all pixels on the feature map generated by the second image to generate a four-dimensional block of size WxHxWxH. Meanwhile, the average pooling method is used for down-sampling, the down-sampling kernel is {1,2,4,8}, generating four layers of (C^1 ,C^2 ,C^3 ,C^4). This is a pyramid kind operation, which is used to put attention on the similarity of different scales, ensuring that both small movements and strenuous movements can be simultaneously detected. Finally, the L layer uses the look-up table method, generating a feature based on the relevant pyramid. The feature map, the feature map obtained by the context extractor and the optical flow are used as the input of the GRU, and the GRU structure is used to iterate the optical flow, continuously optimize to approximate real optical flow.

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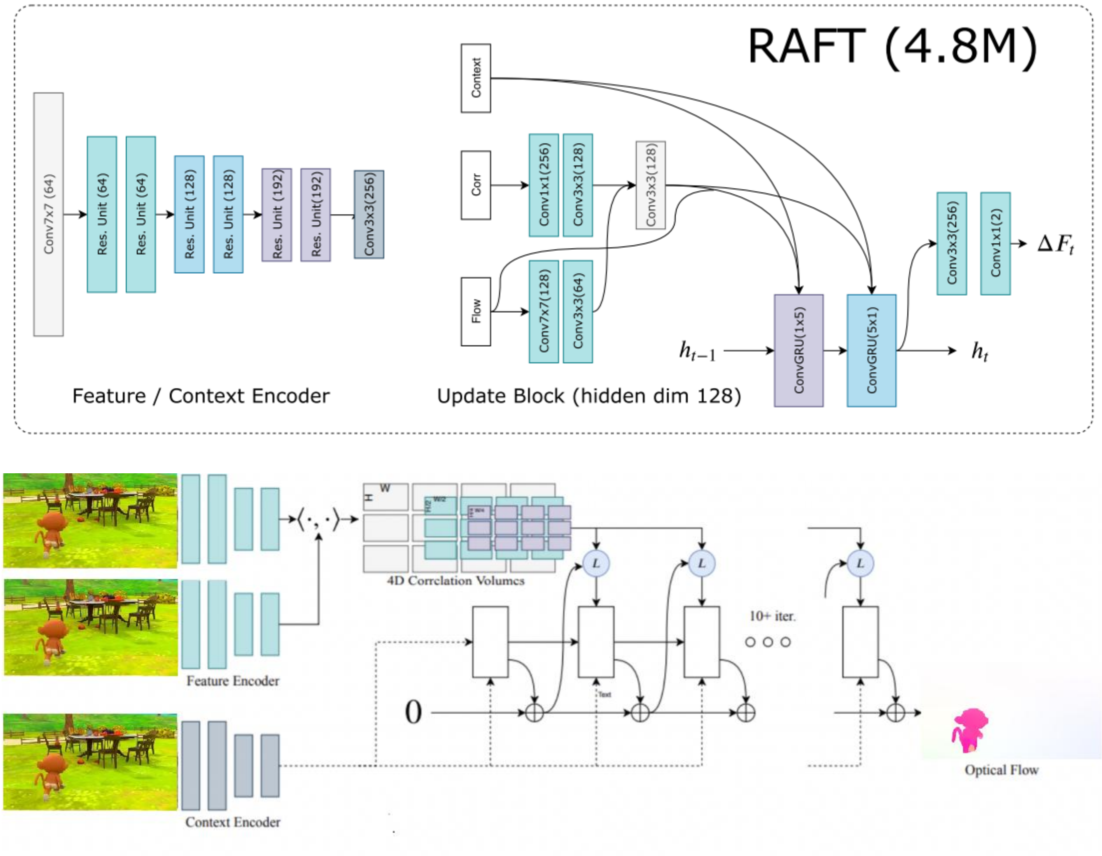

Figure 2 Network structure for RAFT

2.3 Small animal detection pipeline

The optical flow method uses the changes of pixels in the time domain in the image sequence and the correlation between adjacent frames, calculating the motion information of objects between adjacent frames according to the correspondence between the previous frame and the current frame. Figure 3 shows a flow chart of small animal intrusion detection, once the camera collects video data, it first obtains two frames of data with an interval of 1 second by decoding the video stream, then undergoes image preprocessing such as enhancement of contrast, and finally sends it to the RAFT network to determine whether there is a small animal intrusion. If a small animal is invading, the alarm will be dealt with and the picture will be saved, if not, the image will be repeatedly taken at an interval of 1 second.

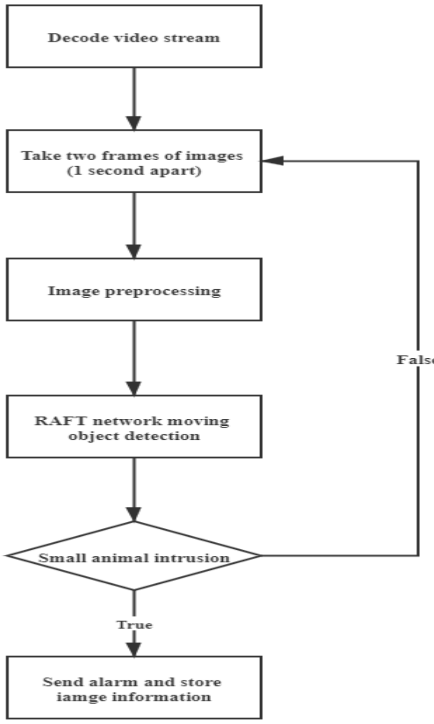

Figure 3 Small animal intrusion detection flow chart

III. Experiment Results and Analysis

As shown in Figure 4, it is the detection result of small animals using RAFT. For low-speed moving objects, the boundary can be detected. Different colors reflect the direction of the optical flow, and the brightness represents the size of the optical flow. A target with a moving speed of 0 such as the lion and giraffe in (b) will not be detected, while there is a small movement in some areas of the elephant, so it can be detected. However, since the elephant as a whole has no movement, the outline of the elephant cannot be detected. The experimental results match with our expectation.

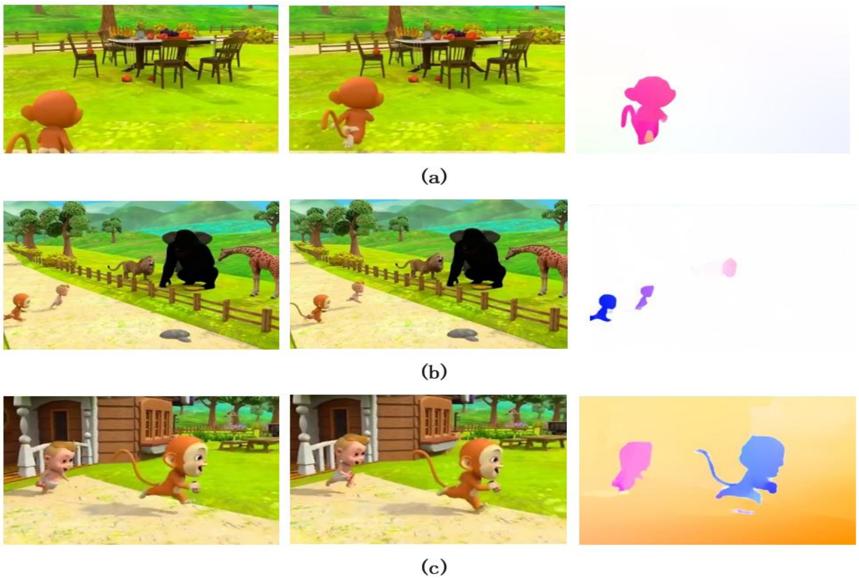

Figure 4 RAFT test results

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